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(54) Preventing carbonation in concrete and the like.

(57) An alkaline passive layer is maintained in contact with iron or steel reinforcement members in concrete structures by providing a CO_2-barrier over substantially all air-contacting surfaces of the structure to prevent carbonation and loss of alkalinity, at least part of the barrier being water vapour-permeable and comprising an alkali metal carbonate and a carboxylic acid so that CO_2 inflow is reduced or prevented whilst outflow of interstitial water vapour is allowed.

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PREVENTING CARBONATION IN CONCRETE AND THE LIKE

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The invention relates to a method of preventing or reducing the carbonation which takes place in cement products such as concrete over a period.

Reinforced concrete is made by mixing cement, aggregate and water and curing the resulting mixture after shuttering around steel reinforcement members. Upon curing and attainment of full strength, the concrete is alkaline in nature with alkaline material in contact with the steel reinforcement members forming a passive layer which protects the steel from rusting by prevention of oxidation.

Over a period of time, however, it has been found that atmospheric carbon dioxide and moisture cause a carbonation reaction with alkaline material in the concrete and this reaction gradually consumes the sources of alkalinity. The carbonate reaction generally commences at the extremities of the concrete forming a gradually inwardly-moving interface between carbonated and alkaline regions of concrete. Ultimately the passive layer is destroyed and the reinforcement in the concrete becomes vulnerable to rusting, especially if the relative humidity is above 40%, initially rupturing the body of the concrete matrix because of the increased volume of the oxidation products but eventually corroding the steel to the point where the reinforcement is too weak to enable structural members made of the concrete to carry their design load.

The carbonation reaction is temperature-dependent so that in hot climates with high relative humidity, such as exist in the Middle East, corrosion of steel reinforcement in reinforced concrete structures occurs relatively soon after completion of the structure and can commonly bring about structural failure in buildings within ten years or less of completion.

The reaction also takes place more quickly in concrete which is relatively low in density due to air voids.

The carbonation reaction requires the presence of carbon dioxide which normally passes to the site of reaction by permeation through the concrete. With this in mind, attempts have been made to prevent the entry of carbon dioxide and oxygen into concrete by applying a surface coating as a carbon dioxide and oxygen barrier, for example a coating of an epoxy resin composition. These attempts have been successful in prevention of carbon dioxide and oxygen's permeation but have involved considerable expenditure in terms of materials. Moreover, these attempts have resulted in problems caused by a build up of condensation of water vapour interstitially within reinforced concrete structures due to the moisture vapour barrier effect of the surface coating.

Certain compositions containing cement, sand, sodium carbonate and an organic acid have in the past been used successfully for waterproofing concrete surfaces such as floors, basement walls and water-retaining structures. It has now been found that these compositions can be used successfully to prevent carbon dioxide and oxygen's permeation into concrete structures whilst at the same time allowing the structure to breathe so that interstitial condensation of water is avoided. The invention is based on this finding.

The invention provides a method of substantially inhibiting or completely preventing consumption by carbonation reaction of alkaline material in a structure of cement-based material reinforced with steel members (eg. steel members) subject to corrosion in the absence of alkalinity, the method comprising applying over as far as possible all air-contacting surfaces (eg. substantially all such surfaces) of the said structure a carbon dioxide and oxygen barrier at least part of which is a water vapour-permeable layer provided to enable passage of water vapour

from the interstices of the structure and comprising a cement-based barrier composition containing an alkali metal carbonate and a carboxylic acid.

The method of invention is particularly applicable to iron- or steel-reinforced load-bearing concrete structures where the consequences of structural failure due to corrosion of reinforcement members is especially damaging. However, the method is also applicable to other cement-based structures. The method of invention is applicable as well to new structures as to older structures where the carbonation process has not yet done incurable damage.

The water vapour-permeable layer will normally constitute, as far as possible, the whole of the carbon dioxide barrier although part may be an alternative carbon dioxide and oxygen barrier material, for example bituminous or plastics coatings such as an epoxy resin composition. A water-tower, for example, may be provided on its internal water-contacting surfaces with a water-impermeable coating also serving as a carbon dioxide and oxygen barrier and on its external surfaces with a layer of the cement-based barrier composition.

The alkali metal carbonate in the cement-based barrier composition will normally be sodium carbonate.

The carboxylic acid will usually be a dibasic carboxylic acid, for example citric acid or tartaric acid, tartaric acid being most preferred.

The combined amount of alkali metal carbonate and carboxylic acid may be small, for example as low as 10 parts by weight per 3,000 parts by weight of other contituents with the charge of these two materials comprising, for example, 50% to 95% by weight sodium or other carbonate and 5% to 50% by weight of tartaric or other organic acid. However, for practically significant inhibition of the carbonation reaction the cement-based barrier composition will contain from 5% to 35% by weight sodium or other carbonate and 1% to 15% by

weight carboxylic acid (e.g., tartaric acid). Especially preferred is the use of 7% to 15% carbonate and 1% to 10% carboxylic acid.

The balance of the cement-based barrier composition will normally comprise cement and a filler, together optionally with one or more additives, although cement only may make up the balance if so desired. The filler may be an aggregate filler, for example sand or another fine aggregate filler and/or a light-weight aggregate (e.g., hollow glass particles or exfoliated vermiculite). Fuel ash may be present as filler, particularly in combination with sand (e.g., 5% to 10% ash and a balance of sand). Pulverized waterglass may be present as filler.

Cement will in general make up from 35% to 75% by weight of the cement-based barrier composition (e.g., 40% to 60%, for example about 50%).

The cement-based barrier composition may include one or more additives for any desired special purpose. For example, a plasticizer or bonding agent may be present. Also additives such as sodium or potassium salts of methylsilicic acid can be used. The composition may furthermore include an anti-microbral agent such as a mixture of methylene-bis-(4-chlorophenol); di(p-diethylamino)-triphenylcarbinol anhydride; chlorinated salicyl alcohol; o-chloro cresol; m-chloro toluene; m-chlorosalicylic acid sodium salt and polyoxy-methylene sorbitan monooleate.

A preferred form of cement-based barrier composition for use in the method of the invention comprises 45% to 55% by weight cement, 10% to 13% by weight carbonate, 1% to 3% by weight carboxylic acid and a balance consisting of filler.

Especially preferred is a composition comprising approximately 50% by weight cement, approximately 11.5% sodium carbonate, approximately 2% tartaric and a balance consisting of filler (e.g. sand and silica in proportions, for example, of about 5 : 1 by weight)

The cement-based barrier composition may normally be mixed up with water and applied by brushing, trowelling or spraying. Alternatively, the composition may be provided _in situ_ when forming the reinforced structure, for instance as a powder either dusted or broadcast below concrete slabs or on top of same and then floated into the concrete.

The cement-based barrier composition will in general be in the form of a discrete layer of material serving as a carbon dioxide and oxygen barrier but it is possible also to use the composition as an additive to a concrete or sand/cement mixture.

The following specific Example sets forth a typical example of a formulation for use as a cement-based barrier composition in the method of the invention:-

Constituent	% by weight
Cement	50
Silica sand	30
Filler	5.75
Sodium carbonate	11.50
Tartaric acid	2.03
Sodium siliconate	0.72

The invention includes within its scope a method of making a building structure comprising steel- or iron-reinforced cement-based structural members which method includes provision of said structural members with a carbon dioxide and oxygen barrier comprising a cement-based barrier composition containing sodium or other alkali metal carbonate and tartaric or other carboxylic acid, the said barrier being applied as far as possible to all surfaces of the said building structure (if not covered by other carbon dioxide or vapour barrier) even if not exposed to rain or other moisture-laden weather element.

The invention includes within its scope a method of making a building structure comprising steel or iron-reinforced cement-based structural member(s) which method includes provision of said structural members with a barrier layer comprising at least over part of said structural member a cement-based barrier compositon containing sodium or other alkali metal carbonate and tartaric or other carboxylic acid, said barrier layer being present over surfaces of said building structure not exposed to rain or other moisture-laden weather element or otherwise not required to be protected against moisture.

CLAIMS:

1. A method of substantially inhibiting or completely preventing consumption by carbonation reaction of alkaline material in a structure of cement-based material reinforced with members subject to corrosion in the absence of alkalinity, the method comprising applying over substantially all air-contacting surfaces of the said structure a carbon dioxide and oxygen barrier at least part of which is a water vapour-permeable layer provided to enable passage of water vapour from the interstices of the structure and comprising a cement-based barrier composition containing an alkali metal carbonate and a carboxylic acid.

2. A method as claimed in Claim 1 wherein the cement-based barrier composition contains from 5% to 35% by weight sodium or other carbonate and from 1% to 15% by weight of carboxylic acid.

3. A method as claimed in Claim 1 or Claim 2 wherein the cement-based barrier composition comprises from 7% to 15% by weight sodium or other carbonate and from 1% to 10% by weight of carboxylic acid.

4. A method as claimed in any one of Claims 1-3 wherein the cement-based barrier composition comprises from 45% to 55% by weight cement, from 10% to 13% by weight sodium or other carbonate, from 1% to 3% by weight carboxylic acid and a balance consisting of filler.